TRAINING OSCILLOSCOPE

EXPERIMENT PROCEDURE

- **Investigating the deflection of an electron beam in an electric field.**
- **Investigating the deflection of an electron beam in a magnetic field.**
- **Demonstrating the display of signals on an oscilloscope, using the periodic signal from a function generator.**
- **Calibrating the frequency control of the sawtooth generator.**

OBJECTIVE

Study the physical principles of the time-resolved display of electrical signals using an oscilloscope

SUMMARY

The student oscilloscope can be used to study the physical principles of the time-resolved display of electrical signals on a fluorescent screen. In a Braun tube, a focused electron beam is generated, and the point at which it falls on the fluorescent screen is observed as a spot of green light. When the electron beam is deflected by a sawtooth voltage applied between a pair of plates, it moves at a constant speed from left to right across the screen, then flies back to the starting point. This process is repeated cyclically at a frequency that can be adjusted. The time-dependent voltage that is to be displayed is applied to a coil outside the tube, so that the beam is deflected vertically in the magnetic field of the coil. The time-dependence of the signal is resolved by the simultaneous horizontal motion of the electron beam and displayed on the fluorescent screen.

REQUIRED APPARATUS

Quantity	Description	Number
1	Training Oscilloscope	**1000902**
1	DC Power Supply 0 – 500 V (230 V, 50/60 Hz)	**1003308 or**
	DC Power Supply 0 – 500 V (115 V, 50/60 Hz)	**1003307**
1	Function Generator FG 100 (230 V, 50/60 Hz)	**1009957 or**
	Function Generator FG 100 (115 V, 50/60 Hz)	**1009956**
1	Set of 15 Safety Experiment Leads, 75 cm	**1002843**

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BASIC PRINCIPLES

An important application of thermionic emission in a high vacuum is the cathode ray oscilloscope, in which the Braun tube is an essential component. In the form used in the student oscilloscope, the electron-optical system of the Braun tube, which is visible from the outside, consists of a thermionic cathode surrounded by a "Wehnelt cylinder" and a pinhole disc at the anode potential. A proportion of the electrons that are accelerated towards the anode pass through the pinhole disc and form a beam, which is observed on the tube's fluorescent screen as a green spot of light. Because the tube is filled with neon at a low pressure, the electron beam is concentrated through collisions with gas atoms, and is visible as thin threads emitting reddish light. A negative voltage that is applied to the Wehnelt cylinder also contributes to the concentration of the beam. Technical oscilloscopes usually have additional arrangements for post-acceleration (intensification) and focusing of the beam, but for simplicity and clarity these are not present in the student oscilloscope.

Behind the anode, there is a pair of plates with their planes parallel to the electron beam, which can be connected to a sawtooth generator (see Fig. 1). The electric field produced by the sawtooth voltage $U_X(t)$ deflects the beam horizontally, so that it moves across the fluorescent screen from left to right at a constant speed, then flies back to the starting point. This process is repeated cyclically at a frequency that can be adjusted.

During its left-to-right movement, the electron beam can also be deflected vertically by a magnetic field, and for this a voltage $U_Y(t)$ is applied to the coils that are external to the tube. If this voltage is time-dependent, the time-resolved variations are displayed on the screen (see Fig. 2). Such time-dependent voltages might be, for example, the periodic output voltage from a function generator, or the amplified signals from a microphone.

In the experiment, the periodic signals from a function generator are investigated. The most useful display is obtained when the sawtooth frequency is adjusted so that its ratio to that of the function generator is a whole number.

EVALUATION

If the frequencies are adjusted so that exactly one cycle of the signal is displayed on the screen, then its frequency matches that of the sawtooth generator.

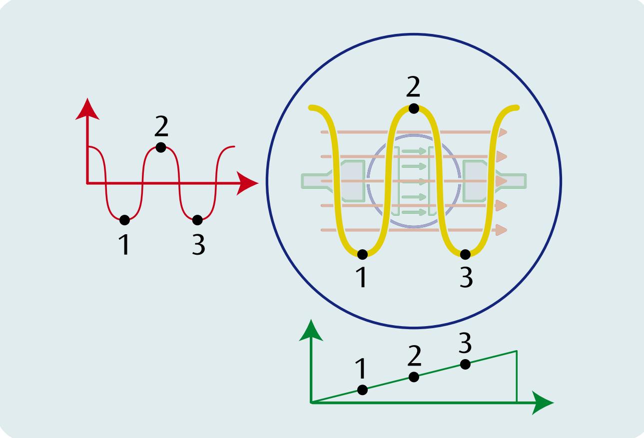

Fig. 2: Time-resolved display of a periodic signal

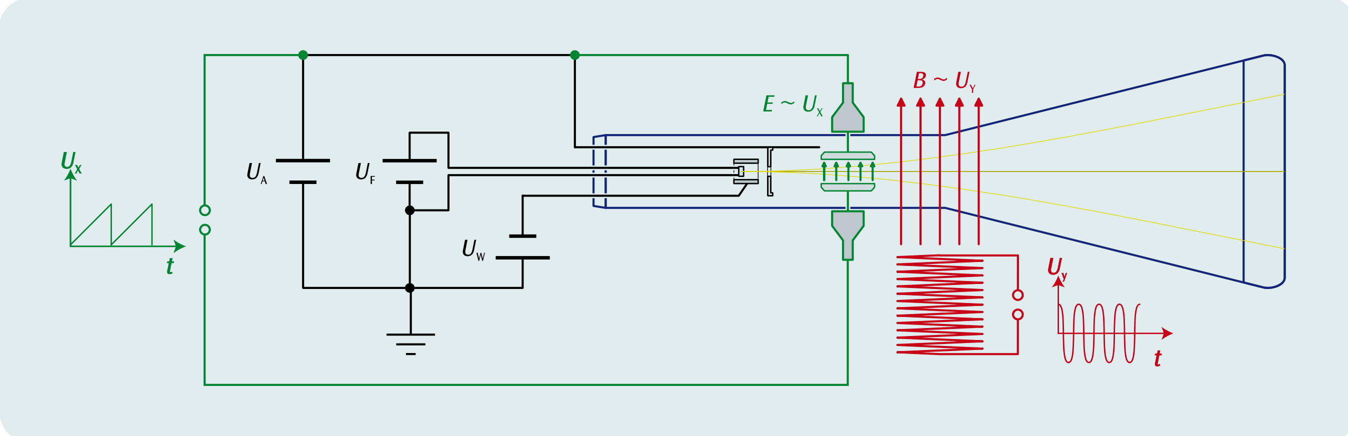

Fig. 1: Schematic diagram of the student oscilloscope, viewed from above